What is claimed is:

1. A method of working an optical element for producing an optical element having a microscopic pattern comprising the step of drawing a pattern, corresponding to an optical element, for forming a specified pattern on a base material including a layer on which a pattern is to be drawn, wherein said layer of pattern drawing object has a curved surface, and said specified pattern is drawn by the application of an electron beam to said layer of pattern drawing object.

2. A method of working an optical element as set forth in claim 1, wherein said specified pattern is formed by a control of the exposure energy quantity of an electron beam.

3. A method of working an optical element as set forth in claim 2, wherein the depth of working is varied by the aforesaid control of the exposure energy quantity of an electron beam.

4. A method of working an optical element as set forth in claim 3, wherein the aforesaid exposure energy quantity of an

electron beam is controlled in such a way as to make the depth of working vary within the depth of focus at a focus position of an electron beam.

5. A method of working an optical element as set forth in claim 1, wherein the adjustment of the focus position of the aforesaid electron beam with respect to the base material is practiced by a control to move the height position of the depth of focus through controlling an electron lens.

6. A method of working an optical element as set forth in claim 1, wherein the aforesaid electron beam is applied to a resist layer on a base material.

7. A method of working an optical element as set forth in claim 1, further comprising the steps of

forming a metal die on the basis of a base material on which the aforesaid specified pattern has been drawn, and

producing an optical element by carrying out injection molding for said metal die.

8. A method of working an optical element as set forth in claim 1, further comprising

a development step to develop a base material to which the aforesaid electron beam has been applied, and

an electroforming step to form a metal die by carrying out electroforming processing on said base material which has been developed.

9. A method of working an optical element as set forth in claim 8, wherein a base material is subjected to an etching process before the aforesaid electroforming processing.

10. A method of working an optical element as set forth in claim 1, wherein pattern drawing by means of the aforesaid electron beam is carried out independently for two base materials, a first and a second metal dies formed by the respective base materials are arranged facing to each other, and an optical element having the aforesaid specified patterns on the respective surfaces is produced by injection molding.

11. A method of working an optical element as set forth in claim 10, wherein a polarized light splitting structure is drawn on one base material and a diffractive grating structure is drawn on the other base material.

12. A method of working an optical element as set forth in claim 10, wherein a birefringence phase structure is drawn on one base material and a diffractive grating structure is drawn on the other base material.

13. A method of pattern drawing for forming a specified pattern on a base material including a layer of pattern drawing object comprising the step of

carrying out the drawing of said specified pattern by applying an electron beam to said layer of pattern drawing object, wherein

said layer of pattern drawing object has a curved surface.

14. A method of pattern drawing on a base material as set forth in claim 13, wherein the aforesaid specified pattern is formed by the control of exposure energy quantity of an electron beam.

15. A method of pattern drawing on a base material as set forth in claim 14, wherein the aforesaid exposure energy quantity is controlled in accordance with the dose quantity.

16. A method of pattern drawing on a base material as set forth in claim 14, wherein the depth of working is varied by a control of the aforesaid exposure energy quantity.

17. A method of pattern drawing on a base material as set forth in claim 16, wherein the aforesaid exposure energy quantity of an electron beam is controlled in such a way as to make the depth of working vary within the depth of focus at a focus position of an electron beam with respect to the base material.

18. A method of pattern drawing on a base material as set forth in claim 13, wherein the drawing of the aforesaid specified pattern is carried out by relatively varying the aforesaid focus position of an electron beam with respect to the base material.

19. A method of pattern drawing on a base material as set forth in claim 18, wherein the aforesaid variation of the focus position is carried out by the adjustment of the aforesaid focus position of an electron beam.

20. A method of pattern drawing on a base material as set forth in claim 19, wherein the aforesaid adjustment of the focus position of an electron beam is practiced by a control to move the height position of the depth of focus through controlling an electron lens.

21. A method of pattern drawing on a base material as set forth in claim 20, wherein the aforesaid adjustment of the focus position of an electron beam is practiced by a control of the electric current value of an electron lens.

22. A method of pattern drawing on a base material as set forth in claim 18, wherein the aforesaid variation of the focus position is carried out by a position adjustment through the movement of said base material.

23. A method of pattern drawing on a base material as set forth in claim 18, wherein the aforesaid variation of the focus position is carried out by any one of the aforesaid adjustment of the focus position of an electron beam and the aforesaid position adjustment through the movement of said base material.

24. A method of pattern drawing on a base material as set forth in claim 23, further comprising a calculation step to calculate at least the height position of the aforesaid pattern drawing position.

25. A method of pattern drawing on a base material as set forth in claim 24, further comprising a pattern drawing step to carry out pattern drawing for the aforesaid layer of pattern drawing object while making the aforesaid position adjustment.

26. A method of pattern drawing on a base material as set forth in claim 25, wherein the aforesaid pattern drawing step includes a pattern drawing step to carry out pattern drawing for one field, which is a unit space in a three-dimensional standard coordinate system, on the basis of the aforesaid pattern drawing position calculated, and a step to carry out, after pattern drawing for the one field is done, pattern drawing while carrying out the aforesaid calculation step and position adjustment step again for another field.

27. A method of pattern drawing on a base material as set forth in claim 24, further comprising a thickness

distribution measurement step to measure the thickness distribution of the base material beforehand.

28. A method of pattern drawing on a base material as set forth in claim 27, wherein, in the aforesaid calculation step, at least the height position of the aforesaid pattern drawing position is calculated on the basis of the aforesaid thickness distribution of the base material.

29. A method of pattern drawing on a base material as set forth in claim 27, further comprising the step of measuring the aforesaid thickness distribution of the base material during the aforesaid application of an electron beam.

30. A method of pattern drawing on a base material as set forth in claim 27, further comprising a reference point measurement step to measure the positions of a plurality of reference points during the aforesaid application of an electron beam, and a correction step to correct the aforesaid thickness distribution on the basis of said positions of reference points during the aforesaid application of an electron beam.

31. A method of pattern drawing on a base material as set forth in claim 30, wherein the aforesaid thickness distribution measurement step includes a step to calculate a first three-dimensional standard coordinate system in respect of said base material on the basis of the aforesaid plurality of reference points on the base material measured beforehand, and a step to calculate at least a first height position of the aforesaid pattern drawing position with respect to said first standard coordinate system, and the aforesaid correction step includes a step to calculate a second three-dimensional standard coordinate system in respect of said base material on the basis of a plurality of reference points measured when said base material is placed on a pattern drawing stage, and a step to calculate a second height position with respect to said second standard coordinate system corresponding to said first height position as the height position at said pattern drawing position of the aforesaid electron beam.

32. A method of pattern drawing on a base material as set forth in claim 30, wherein the aforesaid reference point measurement step includes a step to apply a light beam to said base material from the direction approximately

perpendicular to the aforesaid electron beam, a step to detect the intensity distribution of a light beam passing through said base material on the basis of said light beam, and a step to calculate the height position of said base material on the basis of said intensity distribution of the light beam.

33. A method of pattern drawing on a base material as set forth in claim 30, wherein the aforesaid reference point measurement step includes a step of applying a first light beam to said base material from the direction crossing the aforesaid electron beam, and on the basis of said first light beam, detecting a first intensity distribution of a light beam reflected by a flat portion of said base material, a step of applying a second light beam from the direction approximately perpendicular to the aforesaid electron beam, which is different from the direction of said first light beam, to said base material, and on the basis of said second light beam, detecting a second intensity distribution of a light beam transmitted by said base material, and a step of calculating the height position of said flat portion on the basis of said first intensity distribution, and calculating the height position of a point on a curved surface portion

projecting from said flat portion of said base material on the basis of said second intensity distribution.

34. A method of pattern drawing on a base material as set forth in claim 24, wherein the aforesaid calculation step includes a step to calculate a first three-dimensional standard coordinate system in respect of said base material on the basis of a plurality of reference points on said base material measured beforehand, a step to calculate at least a first height position of the aforesaid pattern drawing position with respect to said first standard coordinate system, a step to calculate a second three-dimensional standard coordinate system in respect of said base material on the basis of a plurality of reference points measured when said base material is placed on a pattern drawing stage, and a step to calculate a second height position with respect to said second standard coordinate system corresponding to said first height position as a height position at said pattern drawing position of the aforesaid electron beam.

35. A method of pattern drawing on a base material as set forth in claim 24, wherein the aforesaid calculation step is

carried out during the aforesaid application of an electron beam.

36. A method of pattern drawing on a base material as set forth in claim 23, wherein the aforesaid position adjustment step is carried out during the aforesaid application of an electron beam.

37. A method of pattern drawing on a base material as set forth in claim 13, wherein the aforesaid electron beam is applied to a resist layer on said base material.

38. A method of pattern drawing on a base material as set forth in claim 13, wherein the aforesaid specified pattern to be formed on the aforesaid layer of pattern drawing object corresponds to a specific pattern on an optical element.

39. A method of pattern drawing on a base material as set forth in claim 38, wherein the aforesaid specific pattern includes a diffractive grating structure.

40. A method of pattern drawing on a base material as set forth in claim 39, wherein the aforesaid diffractive grating

structure is formed on the basis of a specified dose quantity distribution corresponding to the scanning position.

41. A method of pattern drawing on a base material as set forth in claim 40, wherein the characteristic of the aforesaid dose quantity distribution is defined beforehand.

42. A method of pattern drawing on a base material as set forth in claim 40, wherein the characteristic of the aforesaid dose quantity distribution is one that is derived in accordance with the angle of inclination of a slope on the aforesaid curved surface portion.

43. A method of pattern drawing on a base material as set forth in claim 38, wherein the aforesaid specific pattern includes a pattern for reducing surface reflection.

44. A method of pattern drawing on a base material as set forth in claim 43, wherein, in forming concave and convex portions for the aforesaid pattern for reducing surface reflection, the dose quantity distribution against scanning position including an additional dose quantity for the pertinent concave or convex portion is calculated on the

basis of the characteristic of the dose quantity distribution, and pattern drawing on said base material is carried out.

45. A method of pattern drawing on a base material as set forth in claim 44, wherein the characteristic of the aforesaid dose quantity distribution is defined beforehand.

46. A method of pattern drawing on a base material as set forth in claim 43, wherein the aforesaid specific pattern includes a diffractive grating structure and the aforesaid pattern for reducing surface reflection.

47. A method of pattern drawing on a base material as set forth in claim 46, wherein at least one blaze unit having a width of the pitch of a diffractive grating is formed with a tilt on the aforesaid curved surface portion of the base material, and concave and convex portions for reducing surface reflection are formed for said one blaze unit.

48. A method of pattern drawing on a base material as set forth in claim 47, wherein the characteristic of the aforesaid dose quantity distribution is derived in accordance

with the angle of inclination of a slope on the aforesaid curved surface.

49. A method of pattern drawing on a base material as set forth in claim 47, wherein at least one blaze unit having a width of the pitch of the aforesaid diffractive grating comprises a side wall portion rising up on said base material at an end position of said blaze unit, and a slope portion formed between neighboring side wall portions of said blaze unit, and the aforesaid concave and convex portions are formed in said slope portion.

50. A method of pattern drawing on a base material as set forth in claim 47, wherein the aforesaid concave and convex portions are composed of a large number of hole portions being tapered.

51. A method of pattern drawing on a base material as set forth in claim 50, wherein pattern drawing is done in such a way as to make the ratio of the area of the hole portions to the area of the aforesaid slope portion a specified proportion.

52. A method of pattern drawing on a base material as set forth in claim 46, wherein at least two blaze units each having a width of the pitch of the aforesaid diffractive grating comprise a side wall portion rising up at one end position of said blaze unit and a slope portion formed between the neighboring side walls each, and the aforesaid reflection reducing structure is formed in such a way as to reduce the reflection of a light beam entering said slope portion or emerging from said slope portion.

53. A method of pattern drawing on a base material as set forth in claim 46, further comprising the steps of

carrying out pattern drawing for the aforesaid curved surface portion of said base material on the basis of the dose quantity distribution against scanning position at the time of forming at least one blaze unit of a diffractive grating with a tilt on the curved surface portion of said base material, and

carrying out pattern drawing of the aforesaid concave and convex portions on the basis of the dose quantity distribution for the pertinent concave and convex portion, at the time of forming concave and convex portions for reducing

surface reflection for said blaze unit of said diffractive grating.

54. A method of pattern drawing on a base material as set forth in claim 43, wherein the aforesaid reflection reducing structure is composed of a plurality of concave and convex portions having a function of structural birefringence.

55. A method of pattern drawing on a base material as set forth in claim 43, wherein the aforesaid reflection reducing structure comprises a plurality of hole portions.

56. A method of pattern drawing on a base material as set forth in claim 55, wherein each of the aforesaid hole portions has a shape being tapered towards the depth direction.

57. A method of pattern drawing on a base material as set forth in claim 55, wherein the aforesaid hole portions are formed to have the respective openings with a diameter of an order of sub-micron.

58. A method of pattern drawing on a base material as set forth in claim 43, wherein the aforesaid reflection reducing structure has a structure to reduce the reflection of a light beam being incident or outgoing.

59. A method of pattern drawing on a base material as set forth in claim 38, wherein the aforesaid specific pattern includes a polarized light splitting structure.

60. A method of pattern drawing on a base material as set forth in claim 59, wherein the aforesaid polarized light splitting structure has a nearly concave and convex shape in a cross-section and has an approximately circular shape in the plan.

61. A method of pattern drawing on a base material as set forth in claim 60, wherein, in the aforesaid polarized light splitting structure, a plurality of a first convex portion having a first width and a second convex portion having a second width which is different from said first width are formed at intervals.

62. A method of pattern drawing on a base material as set forth in claim 60, wherein, in the aforesaid polarized light splitting structure, a first concave and convex portion comprising a first convex portion having a first width and a first concave portion having a second width which is different from said first width being alternately formed, and a second concave portion having a third width which is different from said first width or second width are alternately formed.

63. A method of pattern drawing on a base material as set forth in claim 59, wherein the aforesaid polarized light splitting structure has such a structure as to split an incident or outgoing light beam into at least two polarized light components oscillating in the directions perpendicular to each other in the plane crossing the progressing direction of said light beam.

64. A method of pattern drawing on a base material as set forth in claim 59, wherein the aforesaid polarized light splitting structure has such a structure as to split a parallel bundle of rays into a plurality of bundles of rays

composed of P polarized light and S polarized light having optical paths close to one another respectively.

65. A method of pattern drawing on a base material as set forth in claim 38, wherein the aforesaid specific pattern includes a birefringence phase structure.

66. A method of pattern drawing on a base material as set forth in claim 65, wherein the aforesaid birefringence phase structure has a concave and convex shape in a cross-section and an approximately circular shape in the plan.

67. A method of pattern drawing on a base material as set forth in claim 66, wherein the aforesaid birefringence phase structure is composed of concave portions having a first width and convex portions having a second width which is shorter than said first width being alternately formed.

68. A method of pattern drawing on a base material as set forth in claim 65, wherein the aforesaid birefringence phase structure is such that produces a phase difference between one linearly polarized light wave and the other linearly polarized light wave of the incident or outgoing linearly

polarized light waves oscillating in the directions perpendicular to each other respectively.

69. A method of pattern drawing on a base material as set forth in claim 65, wherein the aforesaid birefringence phase structure is such that produces a phase difference at least between a bundle of rays composed of a P polarized light and a bundle of rays composed of S polarized light out of a plurality of bundles of rays.

70. A pattern drawing apparatus for forming a specified pattern on a base material having a layer of pattern drawing object comprising

a moving means for moving the focus position of an electron beam with respect to said base material in accordance with said layer of pattern drawing object having a curved surface, and

an electron beam applying means for carrying out the drawing of said specified pattern by applying an electron beam to said layer of pattern drawing object.

71. A pattern drawing apparatus as set forth in claim 70, wherein

the aforesaid electron beam applying means comprises an electron lens for making variable the focus position of an electron beam emitted by said electron beam applying means, and

adjusts the electric current value of said electron lens in accordance with the pattern drawing position on the aforesaid base material, to control variably the focus position of said electron beam mentioned in the description of said moving means.

72. A pattern drawing apparatus as set forth in claim 70, further comprising

a carrying table for placing a base material having a curved surface on the surface of pattern drawing object on which a pattern is to be drawn by the application of the aforesaid electron beam, and

a drive means for driving said carrying table, wherein

the focus position of said electron beam mentioned in the description of the aforesaid moving means is variably controlled by moving up and down said carrying table by said drive means in accordance with the pattern drawing position on said base material.

73. A pattern drawing apparatus as set forth in claim 70, wherein the aforesaid measuring means further comprises

a first optical system applying a first irradiation light beam to the aforesaid base material from the oblique direction and receiving a first light beam transmitted through said base material,

a second optical system applying a second irradiation light beam to said base material from the approximately horizontal direction and receiving a second light beam transmitted through said base material,

a measurement calculation means for calculating the height position of the aforesaid pattern drawing position in the flat portion of said base material, on the basis of a first light intensity distribution detected by said first optical system, and calculating the height position of said pattern drawing position in the curved portion projecting from said flat portion of said base material, on the basis of a second light intensity distribution detected by said second optical system.

74. A pattern drawing apparatus as set forth in claim 70, further comprising a second measuring means for measuring the positions of reference points on the aforesaid base material

previously before said base material is placed in said apparatus.

75. An optical element produced by a method as set forth in claim 1.

76. An optical element as set forth in claim 75, comprising a diffractive grating structure on a curved surface.

77. An optical element as set forth in claim 76, further comprising a pattern for reducing surface reflection on the aforesaid curved surface.

78. An optical element as set forth in claim 77, wherein at least one blaze unit having a width of the pitch of a diffractive grating is formed with a tilt on the curved surface portion of the aforesaid base material, and concave and convex portions for reducing surface reflection are provided for said one blaze unit.

79. An optical element as set forth in claim 78, wherein the aforesaid at least one blaze unit having a width of the pitch of a diffractive grating comprises a side wall rising

up at one end position of said blaze unit, and a slope portion formed between neighboring side walls of said blaze unit, and the aforesaid concave and convex portions are provided on said slope portion.

80. An optical element as set forth in claim 78, the aforesaid concave and convex portions are composed of a large number of hole portions being tapered.

81. An optical element produced by a method as set forth in claim 10.

82. An optical element as set forth in claim 81, comprising a diffractive grating structure on the surface of one side and a polarized light splitting structure on the surface of the other side.

83. An optical element as set forth in claim 81, comprising a diffractive grating structure on the surface of one side and a birefringence phase structure on the surface of the other side.

84. An optical element as set forth in claim 81, comprising a birefringence phase structure on the surface of one side and a polarized light splitting structure on the surface of the other side.

85. A base material formed by a method as set forth in claim 13.